# GROUND PENETRATING RADAR

## An Effective Tool for Locating Dry Caves Along a Portion of SR 69 Near Mayer, Yavapai, Arizona

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# Project Location

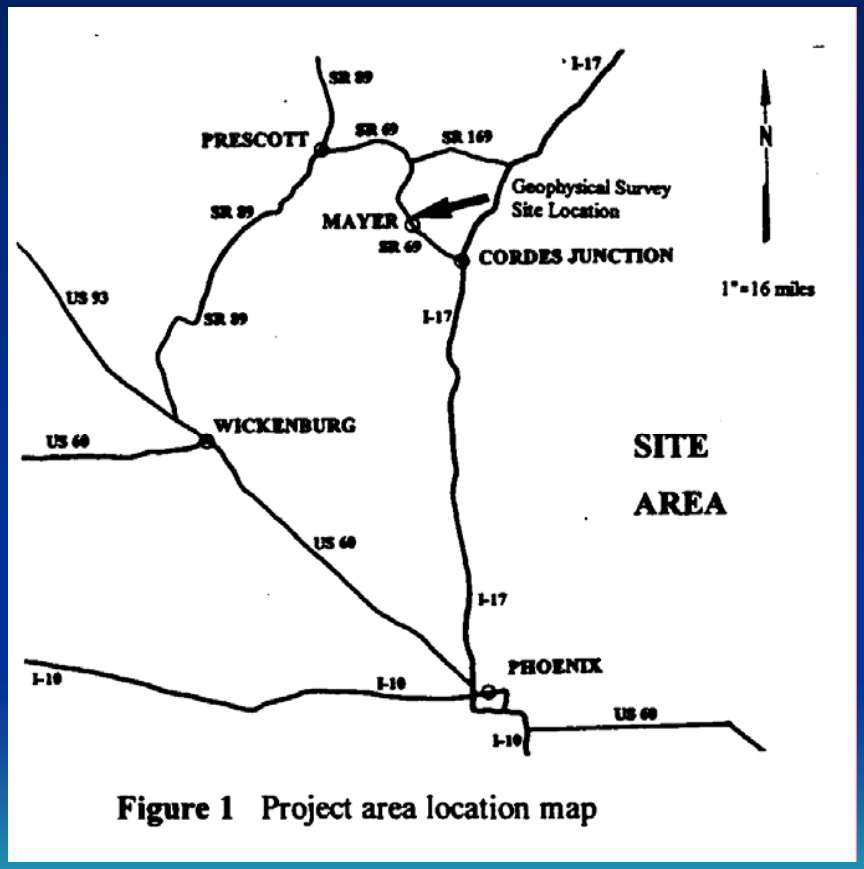



**Figure 1** Project area location map

The area is located on State Route 69 near Milepost 271. About 1 mile north of Mayor Arizona

# *Project History*

- This segment of highway was originally constructed as a realignment of SR 69 between 1947 and 1972 which effectively bypassed the community of Mayer Arizona. This realignment traversed through an intermittently commercial travertine onyx deposit and quarry operation.

# *Project Alignment Prior to Reconstruction*


1992 Photograph exhibiting SR 69 prior to reconstruction. Community of Mayor shown south west of the highway. Light gray areas on either side of the highway indicate quarry sites.

# *Project History*

- The project area prior to 1996 had evolved into a paved rural two-lane route with an improvised third lane. This highway segment was incorporated into a connector route between Interstate I-17 and the recreational areas surrounding Prescott Arizona

# Old Highway Geometry

# *SR 69 Highway Geometry*

- Increased use of the route to access the recreational area surrounding of Prescott demanded that the alignment be widened. ADOT Project STP-029-1 (12) acquired a 340-foot right of way along the existing route. In 1997 excavation was underway to construct a modern two-lane divide 38 foot wide paved highway with a 40-foot wide median.

# *Present Geometry of SR 69*

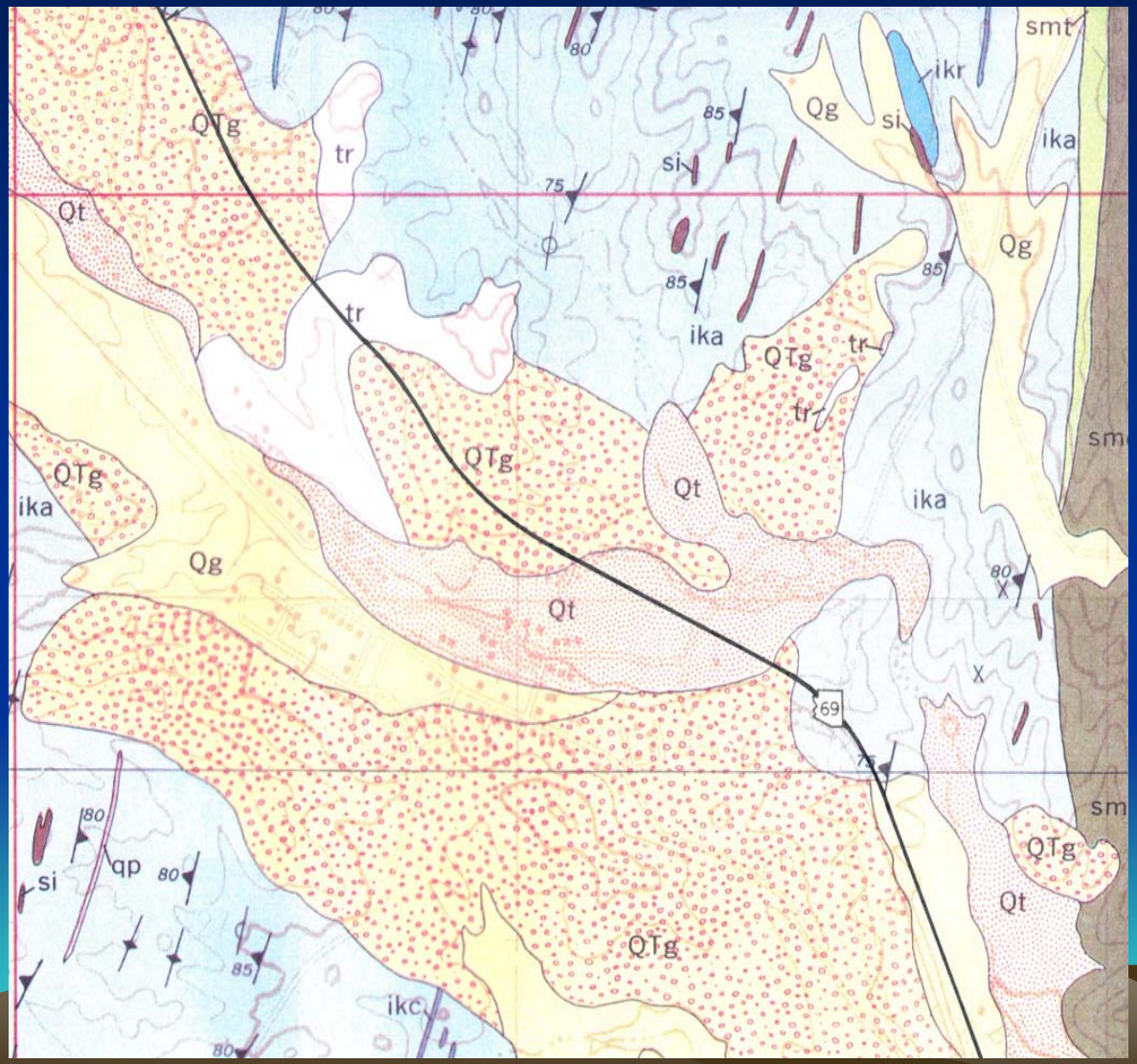
Existing.

Two-lane divide 38 foot wide paved highway with a 40-foot wide median.

# Geology


- The Project area is located in the Arizona Central Highland Transition Zone.
- Region has been exposed to several episodes of complex structural deformation erosion,sedimentation and volcanic activity

# GEOLOGY




- Explanation

| | |
|---|---|
| Qt | Quaternary Age Terrace Deposits |
| Qg | Quaternary Age Younger Gravel |
| QTg | Quaternary/Tertiary Age Gravel |
| tr | Travertine deposits |
| Angular Unconformity | |
| Ika | PreCambrian Iron King Volcanics |

From: Anderson, C.A. & Blacet, P.M.; 1972; Precambrian Geology of the Northern Bradshaw Mountains, Yavapai County, Arizona; U.S. Geological Survey Bulletin 1336; 82 p.

# *Geology*

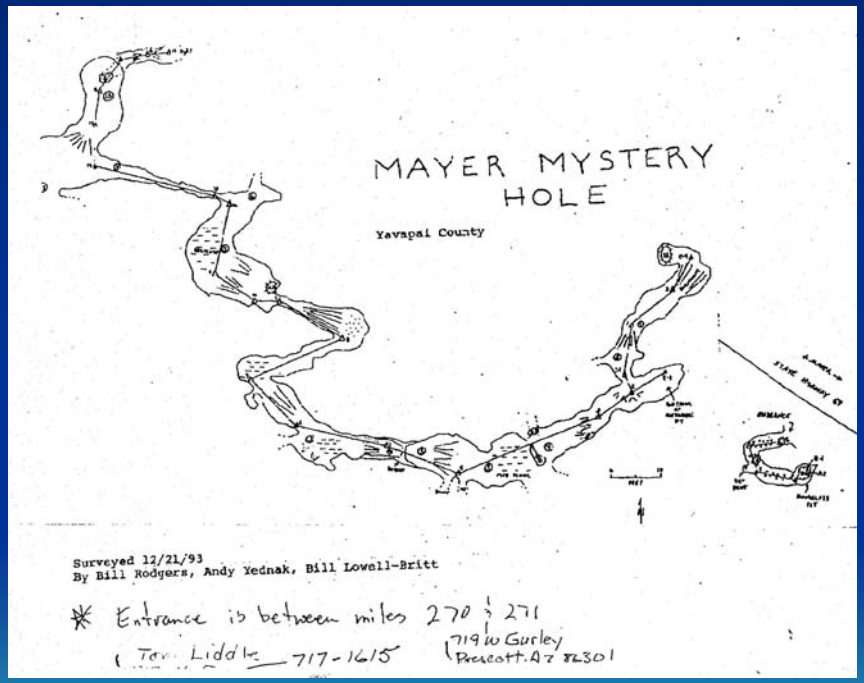
- Although the regional geology is very complex locally only the Tertiary travertine deposits appear to host void formation.
- The travertine has been reported to be the result of hot spring deposits associated with the Tertiary Hickey Volcanic eruptive events
- The travertine directly overlies upturned edges of vertically oriented schist of the deformed PreCambrian Iron King Formation.
- Breccia zone separates the the two units

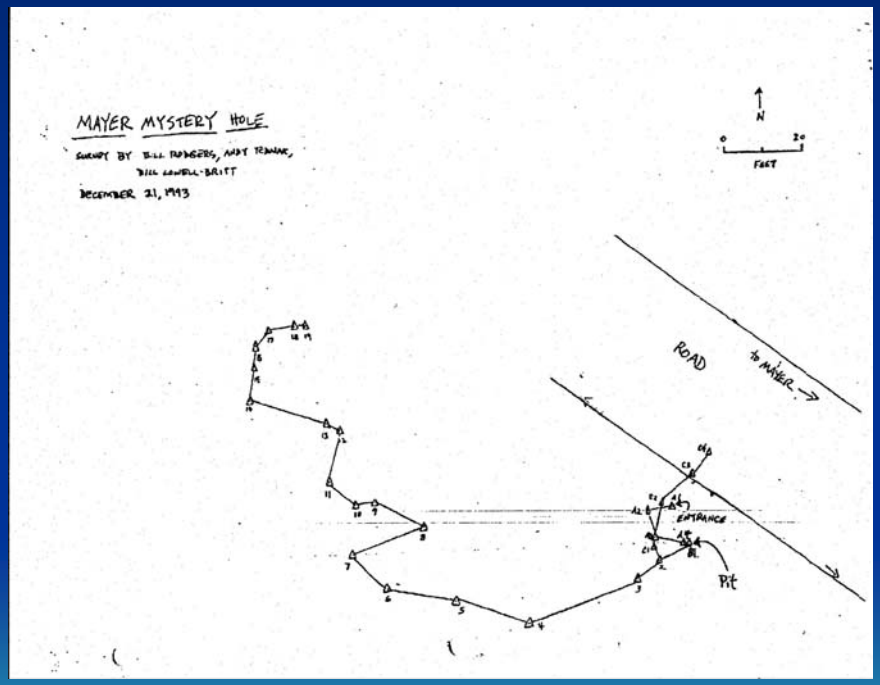
# *Travertine Characteristics*

- Distinctly Banded
- Composed of fine to coarse grained hot spring deposited calcite
- Hardness ranges from soft to very hard
- Horizontally bedded to gently folded
- Massive, poorly jointed
- Thickness 50 – 100 feet
- Voids – Range from small vugs to caves in excess of10ft. In diameter

# 1994 Report of Caves Underlying SR 69

- Cave Survey Maps  Forwarded to the Project Stakeholders



# Void / Collapse Awareness

# GPR Survey Criteria

- Identify cave void structures in area of north and south bound lanes, median, and shoulders.
- Define void limits at least 40 feet below subgrade.
- Confirm void anomalies & refine void dimensions.
- Recommend remediation alternatives.

# GPR Survey System

- Sensors & Software pulse EKKO Model 100.
- 100 MHz antenna w/ estimated beam width of 4 feet each side of profile line.

# GPR Survey Layout

- Define geological/geophysical model.
- Design GPR survey for site specific conditions:
  - No conductive soils
  - Travertine limestone at subgrade elevation or with thin gravelly fill directly on limestone.
  - Potential voids from near-surface to 40 feet below subgrade.
  - Detect voids two feet in diameter or larger.

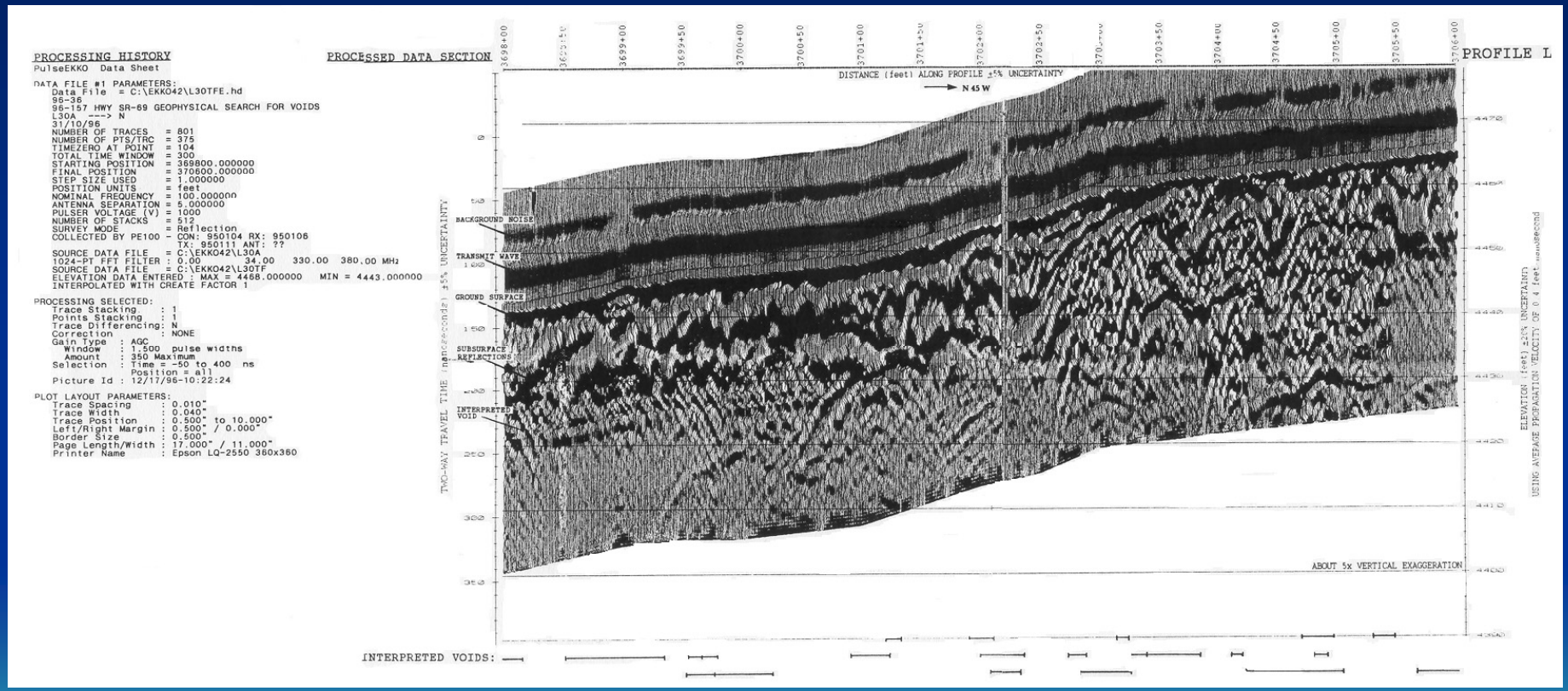
# GPR Survey Layout

- Survey area about 800 feet parallel to alignment & 150 feet shoulder to shoulder.
- Sixteen (16) GPR transects 10 feet apart.
- Data collected at 2-foot intervals

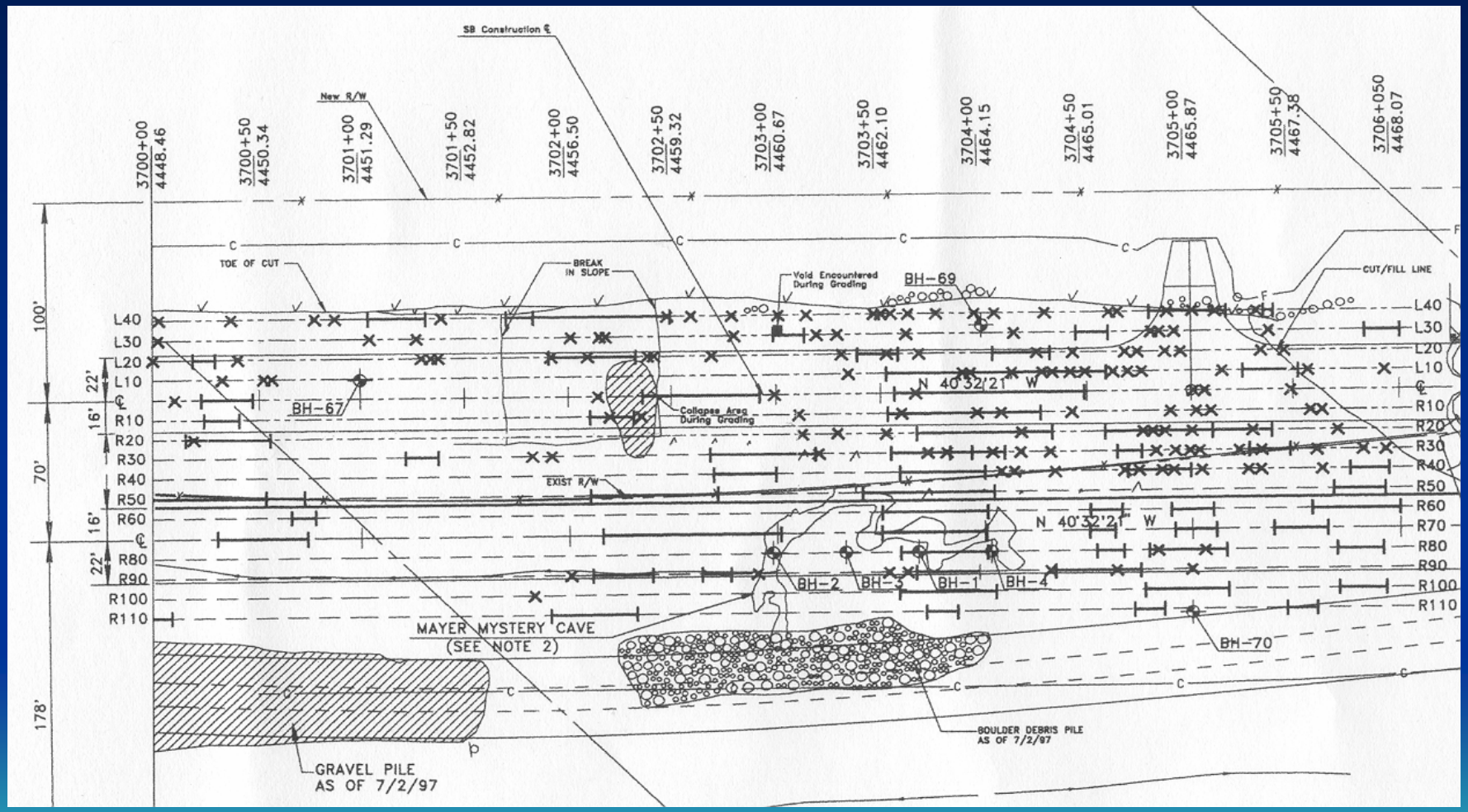
# GPR Survey Results

- Produced 14,000 linear feet of GPR profiles.
- 209 void anomalies interpreted along southbound lanes.
- 257 void anomalies interpreted along southbound lanes.
- Interpreted voids depicted on anomaly plan map.

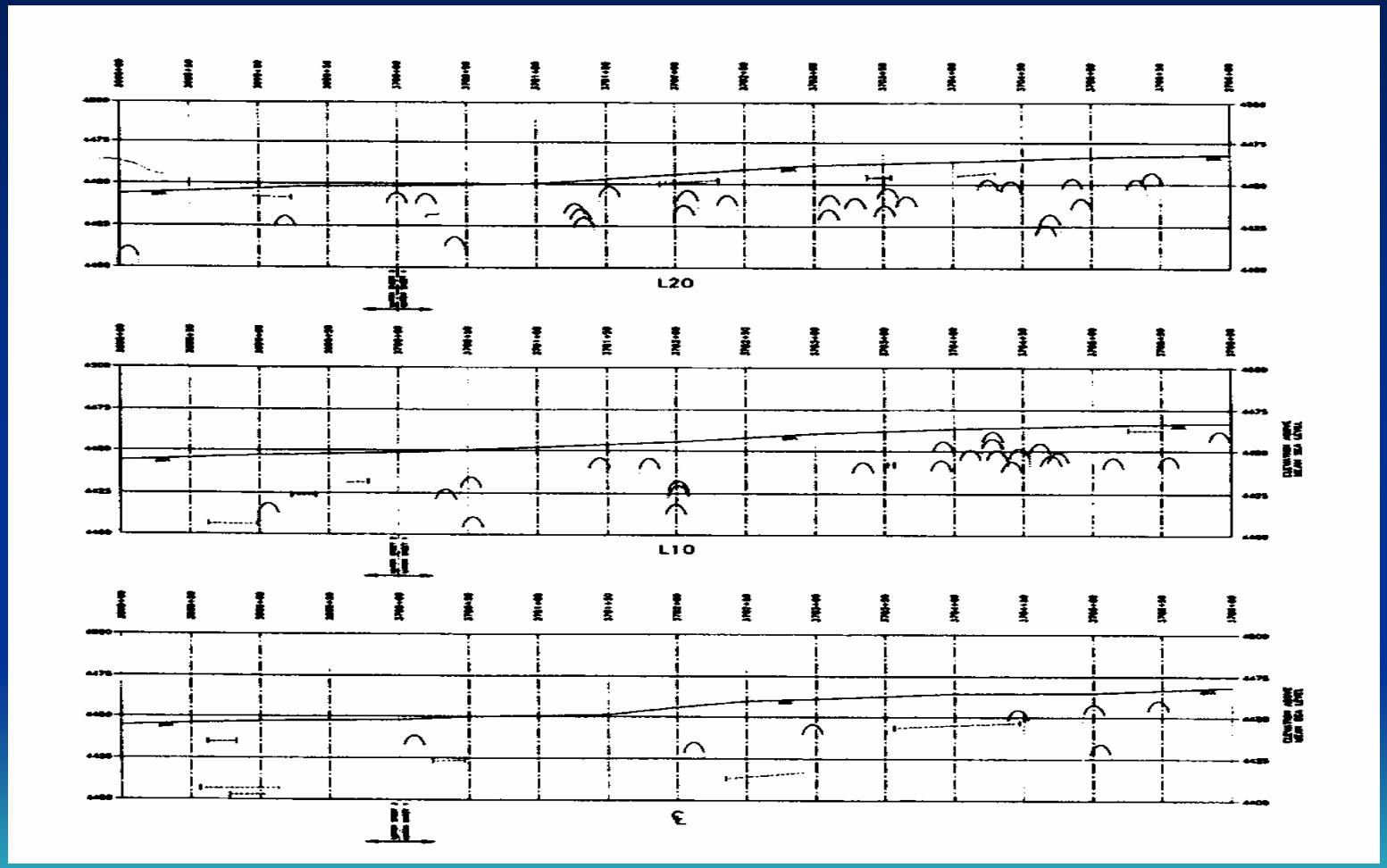
# Typical GPR Profiles



# Anomaly Plan Map



# Alignment Interpreted Void Profiles



# Void Confirmation

- Use air-track drill to investigate anomalies to refine void dimensions of southbound lanes:
  - 191 test holes drilled
  - Void openings confirmed one foot to 26 feet vertically and
  - 5 feet to 60 feet laterally.
  - Ratio of confirmed voids to anomalies about 70 percent


CHA 1100

# Void Confirmation

- Because of the high voids to anomaly ratio at the southbound lanes, only GPR survey anomalies were used to identify northbound lanes remediation sites.
- No verification drilling was conducted within the northbound lanes.

# Void Remediation Program

- Methods selected designed to eliminate major voids within 20 feet of subgrade.
  - For voids 10 feet or larger in diameter, remove or collapse roof by blasting and backfill opening with structural backfill.
  - Grout voids smaller than 10 feet in diameter.
  - Establish survey monuments for subsequent settlement monitoring & roadway performance.


97 1 6


97 1 20

Collapsed roof of cave void.

Cave below roof collapse.


CAT
97 2 6

# In Summary

- Initial GPR survey prior to construction unable to penetrate overburden or conclusively locate voids.
- Realizing voids at grade could be potential hazards, contract special provisions required contractor to evaluate extent of voids.
- Removal of clayey overburden soil significantly improved success of GPR program.

# In Summary

- Field conditions were ideally suited for this geophysical method.
- 70% void to anomaly ratio.
- GPR survey proved to be rapid method to characterize voids in travertine formation.
- Results of GPR survey assisted with the design of a focused remediation program to deal with subgrade voids.